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UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN JOSE DIVISION

THE NVIDIA GPU LITIGATION This Document Relates To: ALL ACTIONS.	Case No. C 08-4312 JW **CLASS ACTION** DECLARATION OF DR. NADER BAGHERZADEH IN SUPPORT OF PLAINTIFFS' OPPOSITION TO BROWN CLASS MEMBERS' MOTION FOR PRELIMINARY INJUNCTION DATE: March 28, 2011 TIME: 9:00 a.m. CTRM: 8, 4th Floor JUDGE: Hon. James Ware

I, NADER BAGHERZADEH, declares:

1. Attached as Exhibit A is my curriculum vitae.

2. My assignment from plaintiffs' counsel was to evaluate the replacement units' comparability to the original models under the settlement terms approved by the Court's Order.

3. Attached as Exhibit B is a true and correct copy of my report entitled "A Report on Nvidia Tablet Replacement," prepared February 2, 2011.

4. Attached as Exhibit C is a true and correct copy of my report entitled "A Report on Nvidia Laptop Replacement," prepared on February 8, 2011.

5. Attached as Exhibit D is a true and correct copy of my report entitled "Report # 3," prepared on March 4, 2011.

6. The above is true of my personal knowledge and if called to do so, I could and would testify thereto.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct. Executed this 4th day of March, 2011 in Irvine, California.

NADER BAGHERZADEH

EXHIBIT A

Nader Bagherzadeh

Professor, Electrical Engineering and Computer Science
Professor (Joint Appointment), Donald Bren School of Information and Computer Science

Education:
B.S., University of Texas,Austin, Electrical Engineering, 1977
M.S., University of Texas,Austin, Electrical Engineering, 1979
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Research:
Dr. Bagherzadeh is interested in low-power and embedded digital signal processing, computer architecture, computer graphics and VLSI design.

Within the area of embedded digital signal processing, Dr. Bagherzadeh is interested in the design and VLSI development of reconfigurable processor architectures and their algorithm mapping for high-performance and low-power applications in mobile communications. This technology can be used for 3G and 4G cellular phones, as well as other telecommunications systems.

In the area of computer graphics, Dr. Bagherzadeh has been involved in the development of a new scheme for creating computer-generated three-dimensional models of a scene based on previously recorded images captured with a standard digital video camera. These models can be used for military and civilian simulator applications, as well as movie special effects.

In the area of low-power system design, Dr. Bagherzadeh has developed a software tool for scheduling and planning mission tasks to achieve power and performance objectives. This technology is targeted for planetary missions of autonomous spacecraft as well as for unmanned military vehicles.

Research topics:
Parallel processing; Computer architecture

Links:
http://www.eng.uci.edu/comp.arch/nader.html

Hats Off Graduates!

Manufacturing a Blade Traffic Sensor

Lower Engineering Quad

EXHIBIT B

A Report on Nvidia Tablet Replacement

By: Nader Bagherzadeh

Subject: Replacement of the original tablet Pavilion tx 1000 with T101MT-EU17-BK.

In this report, the replacement unit will be evaluated based on: (1) Graphics Processing Unit (GPU), (2) Screen size, (3) Central Processor Unit (CPU), (4) DRAM, (5) hard disk, (6) optical disk drive (ODD), WLAN, camera and power consumption capabilities.

Hereafter in this report we refer to Pavilion tx 1000 as the "original," and T101MT-EU17-BK as the "replacement."

GPU rating—Original uses GeForce Go 6150 and the replacement uses GMA 3150. Table 1 summarizes some of the key differences between these two GPUs.

Model	GMA 3150 (Pineview)	NVIDIA GeForce Go 6150 (C51MV)
Year	2010	Feb. 1, 2005
Fabrication (nm)	45	90 (or 110)
Bus interface	NA	Hyper Transport 2.0
Memory (MiB)	Shared memory, up to 384	256
Core clock (MHz)	200	425
Memory clock	NA	700
Core Configuration	2 cores running at 200 MHz each. No hardware accelerator for vertex shader	1:2:2:1 (vertex shader:pixel shader: texture mapping unit: render output unit)
Memory	Bandwidth : 5.3 (GB/s)	Bandwidth : 5.6 (GB/s) Bus type : DDR Bus width : 64 (bit)
API support (version)	DirectX 9.0c, OpenGL 1.5	DirectX 9.0c, OpenGL 2.1
Benchmarks		
3DMark01	2567	4243
3DMark03	700	1138
3DMark05	295	631
3DMark06	140	200
Cinebench R10 32bit OpenGL	285	867
Fear min	22	73

Table 1: GPU comparison

3150 is an integrated graphics solution based on the shared memory concept, instead of having its own dedicated graphics memory. It is part of the processor unit, in this case the N450 CPU. It is a newer part using a more advanced fabrication technology (45 nm) than the 6150 (90 nm). The newer technology has more transistors per unit area and is more efficient in terms of MIPS per mW, which corresponds to how much energy is consumed (battery life) to perform a given graphics task. This suggests that at least as far as the battery life is concerned for GPU functions, 3150 is more efficient and will use less power for similar tasks.

The graphics test benchmarks shown at the lower half of Table 1, demonstrate that the replacement unit has a performance rating which is inferior to the original. In all the benchmarks of Table 1, 6150 scores higher than the 3150. Judging from results of Table 1, the reported performance difference could be partially related to core speed differences between these two designs.

Screen size—Original uses a 12" screen whereas the replacement is only 10" wide.

CPU rating—Original has Turion Dual Core TL-64 (2.2 GHz) but the replacement utilizes Intel Atom N450 at 1.66 GHz. Table 2 shows specification comparison for these two CPUs, as well as AMD V140 that is used in the replacement laptop agreement. N450 has a lower operating frequency than TL-64. Also the L2 cache is half as much as TL-64 (512 KB vs. 1024 KB). N450 consumes $1/7^{th}$ of the power of TL-64; this is definitely one of the highlights of this processor. For a tablet that is usually designed for its light weight and long battery operation, having a low power CPU is essential. Another disadvantage in terms of computation power is the fact that TL-64 is a dual core architecture, where N450 is a single core design. This difference in the number of cores is quite apparent from the performance results of running Dhrystone and Whetstone (see Table 2). For these two benchmarks, higher numbers mean better performance.

Having a dual core design helps with improving the performance (see Table 2). TL-64 is almost 4 times more powerful than N450 for some of the benchmarks. It should be mentioned that benchmark analysis may not directly correlate with what a user may experience running certain programs on the platform. It is merely an indication of the capabilities of the processor for those specific benchmarks. For instance, Dhrystone and Whetstone benchmarks are better suited for the dual core Turion, because these programs have certain operations that can be executed in parallel. As for SuperPi benchmarks, these are commonly considered sequential programs and do not benefit as much from the dual core nature of the Turion processor which is the CPU for the original equipment. This benchmark measures the amount of time spent to calculate the number pi up to certain number of digits (e.g, one million digits of pi for benchmark Super PI 1M). The two CPUs perform reasonably close to each other, suggesting that for certain sequential programs the two CPUs have similar performances.

DRAM—Both the original and the replacement use DDR2 DRAMs, except the original unit has (2 Gigs) twice as much DRAM as the replacement (1 Gig). The speed rating of the replacement is 667 MHz for its DDR2 memory, if the original has the same speed rating for the memory, then clearly in this category the

original is superior. However, if the original uses a slower DDR2, then the difference in the total DRAM memory size may not be as noticeable.

Hard disk—The original has more hard disk (200 GB) than the replacement (160 GB), but the replacement unit utilizes a faster disk rated at 5400 RPM, whereas the original's disk spins at 4200 RPM. A faster spinning hard drive makes disk access time shorter, improving performance, which could be limited because of the smaller drive associated with the replacement unit.

ODD—Replacement doesn't have one, but the original came with a LightScribe DVD R/RW optical disk drive.

WLAN— WiFi capability is almost the same for both units, except that the replacement does not have Bluetooth interface which is commonly used for untethered connection to other Bluetooth devices, such as cell phones, printers, etc. Since the replacement has three USB ports, it possible to add this feature by a low cost USB based Bluetooth dongle that is currently priced at around 10 dollars.

Camera—Original uses a 1.5 Mpixel camera, but the replacement uses a 0.3 camera, clearly $1/5^{th}$ of the resolution in terms of number of pixels rendered.

Power consumption—Original is reported to have 4 hours of operation battery capacity, the replacement is reported to last 6.5 hours. Given all the parameters, the replacement is considerably lower powered unit than the original.

Concluding Remarks

Based on what has been published, the replacement unit is truly a tablet platform with much longer battery life operation, lighter weight, touch screen navigation, retractable stylus, and overall a completely new tablet with all the benefits of having a new computer. This replacement will reset the life of the unit for number of years of operation without any expected problems, if the unit is properly handled and maintained. With the expected one year warranty from the manufacturer for the proposed Nvidia replacement tablet, class members could effectively reset the clock on their originals as far as warranty expiration is concerned. On the other hand, the replacement unit has disadvantages in these areas: (1) CPU rating for certain programs that can benefit from the dual core technology, (2) certain GPU capabilities, (3) screen size, (4) camera resolution and (5) ODD functionality.

It is my opinion that since the needs of class members may have been different when they purchased their original computers, it is best to provide an option where class members can choose between two different replacements. This is mainly because the original computer (tx 1000) from the feature set point of view fits somewhere between the replacement tablet and the replacement laptop (CQ56). Therefore, if a class member's needs are better met by a low profile, low power, and light weight unit with tablet features, then they could choose the proposed tablet by Nvidia, namely T101MT-EU17-BK. If a class member is seeking a more performance oriented computer, without any concerns about additional weight or power consumption, then they could choose the CQ56 replacement.

The proposed tablet by Nvidia is more portable and could benefit those that need a low profile unit for accessing the Internet while travelling or attending meetings and have no desire for a larger unit with additional processing power. Moreover, since the proposed tablet has touch screen and retractable stylus

in addition to the keyboard, it is more in line with the current trend of having the convenience of soft keyboard as demonstrated by recent introduction of iPad from Apple and Samsung's Galaxy. On the other hand class members that are after computation intensive applications and computer gaming will benefit more from the CQ56 computation power.

Finally, it should be noted that the amount of computing in terms of Millions of Instructions Per Second (MIPS) per dollar is constantly increasing, meaning every year computers are getting cheaper for a given performance rating (see Figure 1). This is true for almost all the other components of a computer, such as screen, hard disk, DRAM, and other major parts. Therefore, in my opinion this cost reduction per feature set should be considered when comparing replacement units with originals, and it is not necessary to provide a replacement that meets the originals' exact cost as long as the main features are generally comparable.

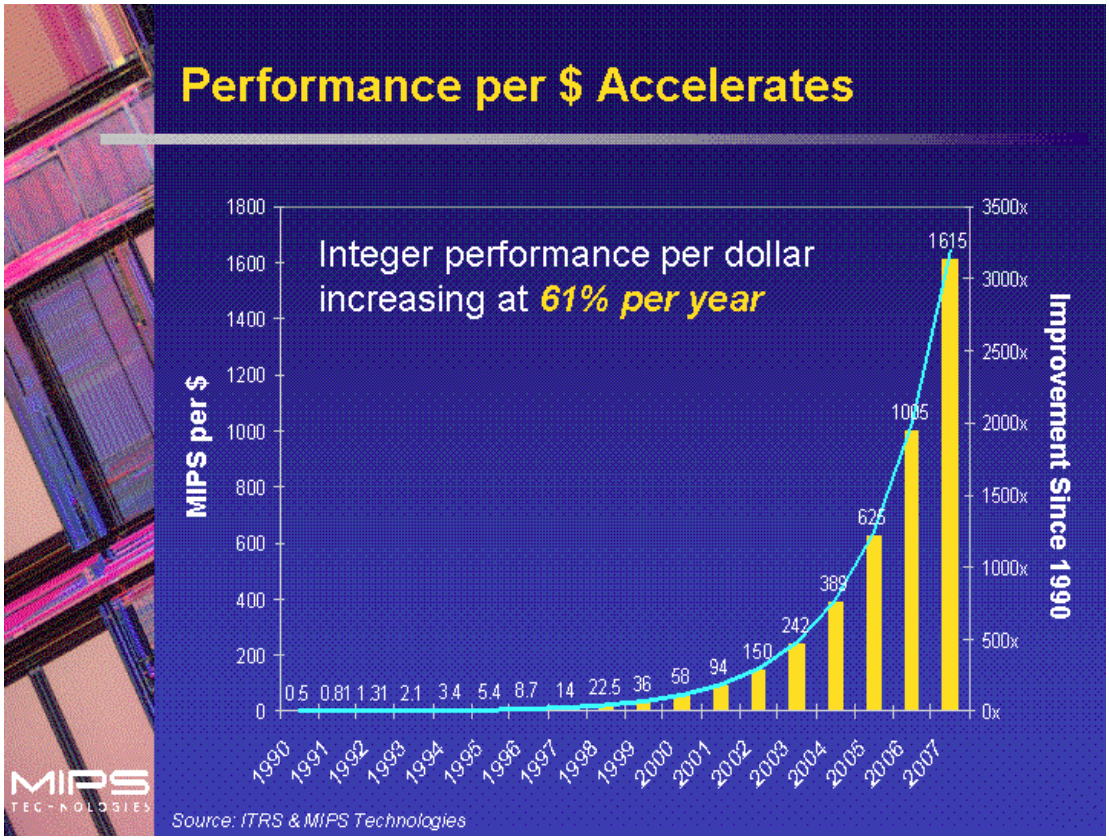


Figure 1 MIPS per dollar plot

	Asus T101MT	Presario CQ56-115DX	Turion Dual Core TL-64 ???
Processor	Intel Atom N450	AMD V140	AMD Turion 64 X2 TL-64
Clock Rate	1660 MHz	2300 MHz	2200 MHz
Front Side Bus	533 MHz	3200 MHz	800 MHz
Level 1 Cache	NA	128 KB	256 KB
Level 2 Cache	512 KB	512 KB	1024 KB
Number of Cores / Threads	1/2	1/1	2/2
Max. Power Consumption (TDP = Thermal Design Power)	5.5 Watt	25 Watt	35 Watt
Manufacturing Technology	45 nm	45 nm	65 nm
Socket	FCBGA559	S1	S1
Features	0.8-1.175V integrated DDR2 (667 MHz) memory controller, integrated GMA 3150 GPU, Hyperthreading, SSE2, SSE3, SSSE3, Intel 64, Enhanced Speedstep, Execute Disable Bit	Integrated DDR3 memory controller, MMX, 3DNow, SSE, SSE2, SSE3, SSE4A, AMD64, Enhanced Virus Protection, Virtualization	1.075
64 Bit	64 Bit support	64 Bit support	64 Bit support
Hardware Virtualization	NA	AMD-V	AMD-V
Announcement Date	12/21/2009	10/04/2010	04/13/2007
Benchmark			
3DMark 06 - CPU	493.3	989.5	1508
Super Pi 1M	41.9	35.2	43
Super Pi 2M	108	80.7	101
Super Pi 32M	1879.6	1870	2339
SiSoft Sandra Dhrystone (MIPS)	4149.9	7830	15864
SiSoft Sandra Whetstone (MFLOPS)	3501.2	7120	13426
PCMark 05: Standard 1024x768	1348.5	2901	3575.7
Cinebench R10: Rendering Single 32Bit	551.9	1912.5	1726

Table 2 CPU comparison chart

EXHIBIT C

A Report on Nvidia Laptop Replacement

By: Nader Bagherzadeh N.B.

Subject: Replacement of the following original laptops: (a) Pavilion dv9000, (b) Pavilion dv6000, (c) Pavilion dv2000, and (d) Presario F500 with Presario CQ56.

Hereafter, in this document we will refer to the replaced laptops (i.e., models a-d) as the "originals," and the replacement laptop as the "replacement." Categorically, this report covers all the performance related attributes of the HP Pavilion and Compaq Presario class computers, as described in Section 1.2 of the settlement agreement document, as long as their GPUs and CPUs are the same as the ones discussed in Tables 1 and 2 of this report, respectively.

In this report, the replacement unit will be evaluated based on: (1) Graphics Processing Unit (GPU) performance, (2) screen size, (3) Central Processing Unit (CPU) rating, (4) DRAM features, (5) hard disk, (6) Optical Disk Drive (ODD), and (7) WLAN capabilities.

GPU rating—Originals all use Nvidia GeForce Go 6150, whereas the replacement uses ATI mobility Radeon HD 4250. Table 1 summarizes some of the key differences between these two GPUs.

GPU Spec	Replacement	Originals
Model	Mobility Radeon HD 4250	NVIDIA GeForce Go 6150
Year	May 1, 2010	Feb. 1, 2005
Fabrication (nm)	55	90
Bus interface	Hyper Transport 3.0	Hyper Transport 2.0
Memory (MiB)	512	System memory (shared)
Core clock (MHz)	560	425
Memory clock	800	700
Core Configuration	40:4:4 (unified shader(vertex, geometry, pixel): texture mapping unit: render output unit)	1:2:2:1 (vertex shader:pixel shader: texture mapping unit: render output unit)
Fillrate	Pixel : 2 .24(GP/s), Texture : 2.24 (GT/s)	Pixel : 0.425(GP/s), Texture : 0.85 (GT/s)
Memory	Bandwidth : 6.4/12.8 (GB/s) Bus type : DDR2, DDR3 Bus width : 64/128 (bit)	System memory HT bus limit

Processing power	44 GFLOPs	NA
API support (version)	DirectX 10.0, OpenGL 2.0	DirectX 9.0c, OpenGL 2.1
Benchmarks		
3DMark 01	7995	4243
3DMark 03	3969	1138
3DMark 05	3237	631
3DMark 06	1362	2000
Cinebench	1940	867

Table 1: GPU comparison

4250 is superior in all aspects of evaluation. It is a newer part using a more advanced fabrication technology (55 nm) than the 6150 (90 nm). The newer technology has more transistors per unit area and is more efficient in terms of MIPS per mW, which corresponds to how much energy is consumed (battery life) to perform a given graphics task. This suggests that at least as far as battery life is concerned for GPU functions, 4250 is more efficient and will use less power for similar tasks.

4250 uses a more advanced bus interface technology (i.e., HT 3.0) than 6150 (i.e., HT 2.0). Table 2 summarizes comparison of HT 3.0 and HT 2.0. HT 3.0 can move data between GPU and memory much faster, allowing for better graphics performance capability.

	Year	Max Freq.	Link Width	Max Aggregate BW (bidirectional)
HT 2.0	2004	1.4 GHz	32 bit	22 GHz
HT 3.0	2006	2.6 GHz	32 bit	41 GHz

Table 2: HT 3.0 vs. HT 2.0

4250 has access to more memory than 6150 (512 MB vs. 256 MB), allowing for storing more image and graphics data. By incorporating more memory, the GPU can processes more data and will require fewer disk accesses to complete a graphics task. Disks are much slower than memories in terms of data access and interface to the processors.

4250's main clock is more than 30% faster than 6150. Although this measure usually does not scale linearly in terms of performance, meaning that 4250 is not 30% faster than 6150, but it is usually a good rule of thumb that a faster clock will improve the performance by a finite percentage, however, the exact number requires more tests. The overall GPU also depends on other parameters such as: the bus interface bandwidth, number of functional units, and graphics memory size.

Memory clock is another important component of the comparison that favors 4250. This is usually referred to as how fast a processor can access the memory to store or retrieve graphics and image data. If

there is a great difference between this access rate and the processor speed, then the unit will not perform as well. 4250 has a memory clock that is 15% faster than 6150, therefore, maintaining the overall speed advantage by balancing the processor-memory speed difference gap.

Screen size—Except for laptop *a*, namely Pavilion dv9000, which has a 17 inch screen, all the originals have a relatively smaller or similar size screen to the replacement unit.

CPU rating—The replacement unit has an AMD V140 @2.2 GHz, whereas all the originals use AMD Turion Dual Core TL-64, except for laptop *d* which uses Sempron 3500 at a lower frequency (1.8 GHz vs. 2.2 GHz). See Table 2 for processor comparisons. Judging from this table a few conclusions can be derived. We are comparing a recently developed single core design (V140) with a dual core that is 5 years old (Turion). V140 has a faster processor memory bus (front side bus is 4 times faster), but having a single core impacts some of the benchmarks. For instance, for the Super PI benchmark, that measures the amount of time spent to calculate number pi up to certain number of digits (e.g., one million digits of pi for benchmark Super PI 1M), V140 beats the competition for all those tests. For this benchmark, the amount of time needed to complete the task is recorded, so a smaller number is better. But for the remaining benchmarks, the dual core Turion has better performance in terms of MIPS, GFLOP, and rendering time (see benchmarks results for Dhrystone, Whetstone, PCMark, Cinebench in Table 2; here the larger number means better performance). Based on this information, it is fair to say that if the program can be parallelized, meaning be able to use both cores to do a computation task, then Turion is better, but if the program is mostly sequential, such as the pi calculation, then a good processor memory bus is helpful, and the V140 wins in this category. Another noteworthy comparison is the power consumption, where V140 consumes almost 30% less power than the Turion.

DRAM—All the originals use DDR2 memories which are a generation behind the DDR3 utilized in the replacement unit. The amount of memory used is the same in all cases (i.e., 2 GB), except for laptop *d*, which had 0.5 GB and is far lower than the replacement unit, impacting overall performance negatively, in particular as it relates to memory accesses and page faults associated with a small memory, requiring more disk accesses than others. DDR3 uses less power and it is faster than DDR2. DDR3 requires 1.5V vs. 1.8V for DDR2, the power consumption is quadratically (V^2) related to the voltage. The data transfer peak for DDR3 is 17 GB/s whereas DDR2 is 8.5 GB/s. DDR3 has a bus speed that is twice as fast as DDR2. Thus, from DRAM capability point of view, the replacement unit is superior to all the originals. DRAM memory is one of the key components for a PC, impacting the overall performance and battery life of a unit.

Hard disk—Hard disk for the replacement unit is similar to most of the originals in terms of size. The only one with half as much disk storage as the replacement is laptop *d*. The RPM for replacement is as good as the best original.

ODD—All the laptops in this comparison, namely originals and the replacement have the same capability, allowing for DVR read and write, at 8X speed.

WLAN—In this category of comparison, originals *a-c* have Bluetooth, but not laptop *d*. However, the replacement unit lacks this capability, but has all the popular WiFi standards namely 802.11b/g/n. Replacement is the only one that has 802.11n, which is a more advanced WiFi standard that is now common on all the new laptops. Bluetooth could become handy for the user that has a cell phone with

Bluetooth radio for untethered connectivity, needed for uploads, software updates, and other features. The replacement unit lacks this feature.

Conclusions

Based on what has been published, the replacement unit is superior in almost all major areas of comparison. Although the replacement unit has a smaller screen size than laptop *a* (Pavilion dv9000), having a new computer which meets or exceeds some of the key performance features should be more than adequate to satisfy the settlement agreement. The replacement unit does not have an embedded Bluetooth functionality. Since there are USB ports on the replacement unit, one could easily purchase a low cost USB based Bluetooth dongle (commonly priced around $10) to achieve this capability. The replacement unit also does not have the flash memory 5-to-1 card reader, but a USB based card reader can be purchased at less than $3 to add this functionality.

It is also my conclusion that the replacement unit provides a reset on the number of years one could have for a fully functional laptop, since an older model laptop (i.e., originals) is being replaced with a current technology unit that is also superior in some key features. The replacement unit clearly increases the life span of the original laptops as far as display, hard drive, keyboard and mother board are concerned, which are usually the first parts on a laptop that fail. The replacement unit because of its 64 bit support is capable of running Windows 7 operating system, allowing class members to utilize the latest operating system from Microsoft which is considered by many to be more stable and efficient than the older ones, such as Windows Vista or Windows XP. Since Windows 7 was released March of 2010, many of the originals were shipped without having this operating system. Given all the benefits of having a new computer, including an overall more powerful machine, the proposed CQ56 should be considered a viable replacement that meets or exceeds nearly all of the specifications of the originals.

In summary, adding up all the advantages and disadvantages, I am of the opinion that the replacement unit is a reasonable choice for the original laptops under consideration, and class members could benefit greatly from having a new computer that is faster than their original computers for certain applications and consumes less power.

	Presario CQ56-115DX	Turion Dual Core TL-64 ???
Processor	AMD V140	AMD Turion 64 X2 TL-64
Clock Rate	2300 MHz	2200 MHz
Front Side Bus	3200 MHz	800 MHz
Level 1 Cache	128 KB	256 KB
Level 2 Cache	512 KB	1024 KB
Number of Cores / Threads	1/1	2/2
Max. Power Consumption (TDP = Thermal Design Power)	25 Watt	35 Watt
Manufacturing Technology	45 nm	65 nm
Socket	S1	S1
Features	Integrated DDR3 memory controller, MMX, 3DNow, SSE, SSE2, SSE3, SSE4A, AMD64, Enhanced Virus Protection, Virtualization	1.075
64 Bit	64 Bit support	64 Bit support
Hardware Virtualization	AMD-V	AMD-V
Announcement Date	10/04/2010	04/13/2007
Benchmark		
3DMark 06 - CPU	989.5	1508 ☺
Super Pi 1M	35.2 ☺	43
Super Pi 2M	80.7 ☺	101
Super Pi 32M	1870 ☺	2339
SiSoft Sandra Dhrystone (MIPS)	7830	15864 ☺
SiSoft Sandra Whetstone (MFLOPS)	7120	13426 ☺
PCMark 05: Standard 1024x768	2901	3575.7 ☺
Cinebench R10: Rendering Single 32Bit	1912.5	1726 ☺

Table 2 CPU Specification comparison for originals and replacement

EXHIBIT D

Report #3

Nader Bagherzadeh

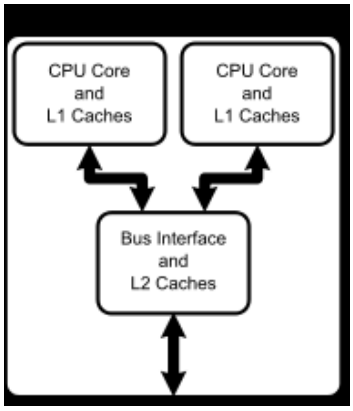
Dual core versus single core

Dual core processors are designed to run two applications simultaneously or a single application on two cores. Taking a single application and making it run on two cores is usually a difficult problem and requires careful distribution of work between the two cores. Finding a quick way of accomplishing this goal requires new programming tools that are not readily available at this time. Therefore, there are few applications that can take advantage of both cores for solving a single problem. These applications are commonly called sequential programs. Since majority of applications are currently sequential, the CQ56 matches or exceeds the dual core performance of the original units for sequential programs, because the single core nature of its processor is much better tuned for this purpose.

At the heart of this comparison is the memory speed. Having a dual core processor but with a slower and older generation DRAM technology, such as the DDR2 in all the original units, the overall performance will be impacted negatively. Since the DDR2 incorporated in all the original laptops is half the speed of DDR3 in the CQ56, dual core processors of the original laptops will not be able to take advantage of their full potential as compared with the CQ56's single core. It is like having a fast car on a bumpy road that prevents the full potential of a car to be realized. On the other hand, CQ56 is much more balanced. It is a fast car on a smooth road, because it uses the DDR3 memory devices.

As for running two separate tasks simultaneously, also called multitasking, where each core runs a different task, it really depends on the operating system. The current Windows 7 operating system which was not available when almost all of the originals were purchased is capable of taking advantage of dual cores for this purpose, but if the single core memory is larger or faster, which is the case for CQ56 as compared to the originals, the dual core advantage will be diminished. Therefore, any comparisons should include the size and speed of the memory, and the speed of the CPU. If a performance benchmark is missing these critical parameters in their comparison charts, then its calculated rating cannot be a true reflection of the actual processor performance.

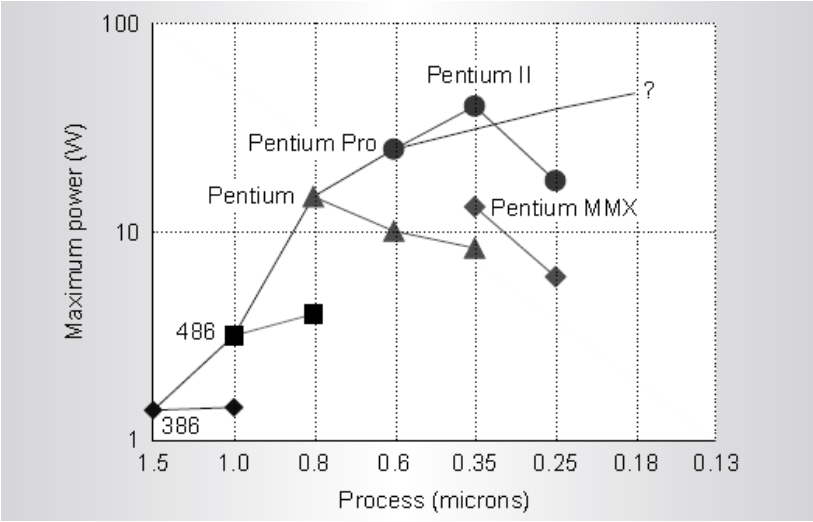
Having a smaller or slower memory will impact how fast a processor can get to the data. This relationship is formulated by: *AMAT = Hit Time + Miss Rate * Miss Penalty*. Which says Average Memory Access Time (AMAT) directly depends on miss penalty that is a function of how fast a DRAM memory can be accessed? A slow DDR2 memory will increase miss penalty and will result in reduced overall performance. Focusing on the number of cores without including the DRAM memory speed is not technically correct and ignores processor memory speed mismatch. This problem is even more profound with multitasking where one core is running say Explorer and the other one is executing Microsoft Word. Since cores share DRAM memory, their individual interaction with the memory could increase the response time from slower DDR2 DRAMs. A single core processor with faster memory is potentially preferable for certain multitasking cases.



The above diagram shows how two cores must compete to access the common memory and a slow DRAM will cause more stalls, making the processor wait for memory to finish its job.

Power efficiency

Every new generation of chip technology is getting faster, smaller, and less power hungry as compared with previous technologies. The entire original laptops use chip fabrication technology that is more than 5 years old. This is a long time where a new generation is introduced roughly every 18 months. Therefore, in terms of power efficiency, the chips used in the original laptops are no match for the CQ56. This is true for DRAM memory chips as well. DDR3s consume less power than DDR2s. In a rough estimate, close to 50% reduction in power can be achieved going from an older technology to a newer one.



As can be seen from the above chart, there is a dramatic power reduction for the same design when it is implemented in a newer technology and the voltage is scaled down, which is a consequence of new

technology scaling. Looking at the Pentium curve, going from .8 to .35 micron, since the voltage was reduced, the newer process is faster and lowers power consumption as compared with older technologies. The fact that class members are getting CQ56 with newer chip technology should reduce their battery usage and time before recharge for similar applications that were used on the originals.

Wireless standards supported

CQ56 supports all the major standard wireless connections, including 802.11n, which was not available for most of the original laptops, since this standard was officially released in October of 2009. This is a more advanced technology allowing users access the wireless network at 5 GHz. The speed of 802.11n at that frequency is twice the speed of 802.11g at 2.4GHz that the original laptops had, making video streaming and online gaming more practical if class members use CQ56 for those applications as oppose to their original older units.

Input and output features

CQ56 has 3 USB 2.0 ports that could be used to add some of the features that were available in the original units but are lacking for the replacement unit. Most users do not need more than 3 ports on their laptops and even if they do in those rare circumstances a very low cost USB port expander can be used without any noticeable performance degradation. Low cost USB based Bluetooth and camera units are available, all under 10 dollars with much better resolution than the original laptops.

Firewire connection is not as popular with PC manufacturers as it is with Mac. The performance of Firewire 400 is typically 15% faster than the USB 2.0, and an average user will not notice the difference for most ordinary tasks. However, USB based peripherals such as hard drives and cameras are cheaper and more common with USB 2.0 interface. Therefore, having a Firewire interface is becoming less desirable and many newer laptops do not have this feature.

Brand name

Since it was acquired by HP in 2002, Compaq products are part of HP family of laptops and it is expected to have the same quality control as HP products. The fact that CQ56 is a brand new unit with standard warranty should assure class members that the proposed replacement will reset the effective life of their unit beyond what they had with their original laptops.

Display

Compaq CQ56 has LED display which measures 15.6" diagonally and comes with resolution of 1366 x 768. It is much newer technology and as wide as almost all of the originals, providing the clarity of LED display with low power consumption. This will result in CQ56's battery lasting longer than most of the originals.

Lightscribe

Many top laptops do not support this feature which allows for the DVD writer to print an optically generated label. It is a convenient feature for those that intend to do a lot of DVD writing which is not usually demanded by an average user. Since there are three USB ports, this capability can be added by purchasing a DVD writer with Lightsrcibe functionality.